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APPLICATION FOR LETTERS PATENT

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Title TUBING USED FOR ENCASING FOOD PRODUCTS AND A
METHOD FOR MANUFACTURING THE TUBING

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This application is a continuation-in-part of ^{abandoned,} application Serial No. 07/730,972, filed July 26, 1991, the disclosure of which application is expressly incorporated herein by reference.

The invention relates to a method of manufacturing a fibrous cellulose casing and a casing manufactured by this method.

Generally, artificial cellulose casings, which are alternatively described as fibrous cellulose casings, or simply as fibre-reinforced casings, et cetera, are manufactured from a long fibre paper base and regenerated cellulose from viscose, that is the soluble sodium cellulose xanthate derivative of cellulose. Before subjecting the paper base to this viscose treatment, or impregnation, it is first wet 15 strengthened by the paper manufacturer, also using regenerated cellulose from viscose, or alternatively using other wet strengthening materials such as polyamide epihalohydrin resins, polyvinyl alcohol, hydroxyethyl cellulose, various synthetically produced latices, et cetera, either used singly or 20 in combination one with another, for example combining regenerated cellulose from viscose and a polyamide epichlorohydrin resin such as Kymene (Kymene is a registered trademark of the Hercules Company of the USA), or using mixtures of these. The chief reason for conferring this wet strength on the part of the paper manufacturer is to enable the paper to retain its integrity and withstand the subsequent heavy impregnation with the strongly alkaline viscose, which is applied by the casing manufacturer, and the subsequent strongly acidic cellulose coagulation and regeneration stage, when the casing is made. And whereas the paper manufacturer may apply only one to six percent regenerated cellulose from viscose and/or other wet-strengthening resins calculated on the basis of total fibre weight, to provide the necessary wet strength, the casing manufacturer usually applies a quantity of viscose of two to three times the total weight of the paper to construct the casing. In the case of the paper, which may weigh 21 g/m² in total, only 0,21 to 1,26 g/m² would

therefore comprise regenerated cellulose from viscose, and the rest fibre, for example, whilst the casing manufacturer would add a further 42 to 63 g/m² regenerated cellulose from viscose in making the casing of total cellulose weight 63 to 84 g/m². In the commercial situation this fibre-reinforced cellulose would be prepared or plasticized with a quantity of 20 to 25 percent glycerol and moisturized with 5 to 10 percent water, to prevent it drying out and becoming brittle prior to use, to an overall basis weight in the example given of between 73,8 and 119 g/m². It is also worth pointing out that the process for making the paper and the process for making the casing are very different in a number of other important ways, for example, in terms of imparting wet-strength to the paper, this is a relatively easy and inexpensive stage for the paper manufacturer, which can be carried on in-line with paper-making, but totally impracticable and prohibitively expensive for the casing manufacturer who requires the paper fully wet-strengthened from the outset. The fibre furnish of the paper substrate used to make fibrous casing is usually a carefully selected choice of abaca fibres, also known as manila hemp fibres, grown in either the Phillipines or Ecuador, which are subjected to a chemical pulping treatment to remove non-cellulosic material and to soften the fibres for paper-making. A part of this fibre may be provided by alternative plant fibre such as sisal, jute, or wood pulp, etc., but not without affecting the casing strength characteristics, usually in a negative way. Papers so prepared, of basis weight between 17 and 28 g/m², are well known in the art for manufacturing fibrous cellulose casings, in the range of size typically from 32 to 163 mm in diameter, or even larger, and usually the basis weight of the paper is increased from 17 to 19 g/m², 19 to 21 g/m², 21 to 23 g/m², and so on in stages, as diameter increases and the need for greater strength increases, that is, since the weight of the sausage product increases exponentially as a function of a squaring of the radius of the sausage.

The casing manufacturer's process usually involves unwinding the paper, supplied in rolls by the paper manufacturer, from an unwind stand, by drawing and forming the paper into the shape of a

tube with overlapping margins, continuously about its longitudinal axis, by bending actions with the assistance of metal guides, and sticking the margins together using viscose just ahead of the fuller impregnation with the bulk viscose which makes up the reinforced cellulose wall of the casing. The composition of this aqueous viscose solution may vary but an example of 7 to 8 weight percent (wt-%) cellulose, as sodium cellulose xanthate of 30 to 33% xanthate sulphur, 4 to 5 wt-% sodium hydroxide and rest water, with a ball-fall viscosity of 50 to 70 seconds (130 mg steel ball of 3,175 mm diameter over a distance of 20 cm) and a Hottenroth ripening (salt) index of 4 to 5 at a temperature of 25 to 30 degrees Celsius may be regarded typical. Once impregnated, the cellulose of the viscose is coagulated and regenerated into cellulose by passing the impregnated tube through a sulphuric acid and salt bath, usually containing ammonium and sodium sulphate mixtures, followed by various acid and water wash baths to complete the regeneration and remove all remaining sulphur from the viscose. Acid strength may vary but 40 to 60 g/liter and a salt strength between 180 and 260 g/l with respect to sodium sulphate and between 10 and 50 g/l with respect to ammonium sulphate may be regarded typical. Before drying this fibre-reinforced tube it is usually passed through a bath containing a dilute aqueous glycerol solution, of 10 to 20 percent strength, to act as a plasticizer for the cellulose. Drying is conducted preferably in an inflated condition, and tension, throughout the casing machine, is maintained such that the diameter of the casing at the outset, that is the diameter provided by the original width of paper in the roll, less that used for overlapping, is reproduced as far as possible in the finished casing tube.

The viscose impregnation may be effected by pouring the viscose onto the outer surface of the paper substrate, well ahead of the acid bath, in order to ensure the paper is thoroughly impregnated prior to regeneration of the cellulose with acid, or alternatively the paper-impregnation stage may be effected from a specially constructed viscose die, wherein the viscose is presented under pressure, through the lips of the die, directly onto the outer surface of the paper base, or substrate, whilst

being temporarily supported during transit across these lips, by a metal ring or cylinder, the gap between ring and die being such as to allow the paper to pass unimpeded, but not of such a width as to fully dissipate the pressure of the viscose before impregnating the paper, this impregnation being completed by continuing the passage of paper between die and supporting ring for some distance within fixed gap dimensions, and thereafter some distance unsupported free through air before entering the acid coagulation and regeneration bath. In the prior art and particularly the prior art insofar as that which pre-dates the original specification of the application in the present family of specifications, first filed in December 1989, the results of such impregnations are invariably very two-sided owing to the resistance to penetration of papers of 17 g/m² and greater, the greater the weight usually the greater the resistance, and the greater the two-sidedness to viscoses, which, at low velocity, are characterized by relatively high solution viscosity. In still another variant, viscose may be supplied to both sides of the paper simultaneously in order to effect a so-called double-viscose-coating, to ensure the paper reinforcement is disposed as far as possible within, and properly covered by viscose, prior to coagulation and regeneration of the cellulose.

Cellulosic tubings produced in these various ways are tough and strong and have low stretch characteristics. For these reasons they may be used as containers, or casings, for sausages, meats, or other articles of food, particularly in applications where size, in terms of diameter control, is a critical parameter, and where highly mechanized sausage stuffing plant places high demands for consistency of performance, and strength with toughness is at a premium. Because of ever greater demands of packaging machinery with higher through-put rates, and in the case of blister-packaged goods, tighter size control of sausage diameters to meet minimum weight criteria, that is to contain so-called give-away meat levels; or alternatively the exact size requirements of subsequent vacuum-packaging equipment, where a chub of product will be subject to maximum length and diameter tolerances in order to fit pre-sized cartons, or other

containers for distribution and retailing. Whilst exact size is achieved from a fibrous casing exhibiting low stretch, this also means that for differences in sausage diameter of only a few millimeters, another size of viscose die has to be used, with all that this entails in terms of separate inventorying on the part of the paper supplier, the casing manufacturer and the sausage maker, etc. In parallel with the development of ever more demanding packaging equipment in the technologically more advanced countries, which in turn has placed ever greater demands on the casing producer to make tougher, stronger and more-size consistent casings, which demands have been met by the fibrous cellulose casing manufacturers, collagen and cellophane casings, or pure cellulose unreinforced by a fibrous substrate, have been developed for less critical market areas where exact size, linked to high through-put rate of product based on highly mechanized stuffing equipment, is not the first or most important selection criterion, but rather flexibility of use and unit cost, have been more important considerations. In this way it can be imagined that these parallel developments have been divergent rather than convergent, which is to say a gap between the two was increasing where, for example, a highly flexible casing but of consistent though by no means exceptional strength was required for mechanized stuffing machinery, but without subsequent packaging equipment also demanding exact size. In this example collagen would have provided the right price level but would not have provided the strength and associated low product breakage rate characteristic of a fibrous casing, and the fibrous casing would be considered over-engineered and too costly.

In recent years this gap has been filled with what may be regarded a hybrid which sought to combine something of the consistency of properties of the fibrous casing but with the elasticity equal to if not superior than that of collagen, whilst being price competitive. The first patent application in which exceptional elasticity was combined with low cost in a fibrous casing, was the specification previously referred to and filed in late 1989. In this application abaca (manila) paper wet-strengthened using regenerated cellulose from viscose, in a

basis weight of no more than 15 g/m², and preferably 13 g/m², was used as the long fibre reinforcement to produce a lightweight fibrous casing product of exceptional elasticity properties combined with an exceptional strength to weight ratio, possessing an exceptionally smooth inner surface which, when combined with the casing's lighter weight, provided a means also for significantly reducing salami processing times as an added benefit, that is from say five weeks to four weeks compared to prior art fibre-reinforced casings.

In the present application which may be regarded a continuation application of this first one in the sense that it seeks to achieve the same collection of unique properties, principally combining high elasticity at a good weight to strength ratio in an overall lightweight construction, which will still allow it to compete in market areas prior to 1989 essentially unavailable to the fibrous cellulose casing, but more traditionally served by collagen or pure cellulose casings, the problem has been to use an alternative paper base which does not rely only on viscose, to provide the initial wet strength by the paper manufacturer for subsequent viscosing operations by the casing manufacturer, but which instead relies on alternative wet-strengthening systems not incorporating viscose.

Now, as will be apparent from a study of the prior art before 1989 insofar as commercially viable fibrous casing manufacture is concerned, the problems quite often were related to improving the wet strength or reducing the variability of strength of paper substrates typically of the order of 20 to 23 g/m², in order that more consistent casing size or strength could be achieved. The use of polyamide-epihalohydrin resin and cationic polyethylene imine resin to provide an improvement in the alkaline wet tensile paper properties, in the US patent No 4,222,821 is one such example. This application does not relate to the manufacture of fibrous cellulose tubings as such but rather to the manufacture of a paper substrate of improved performance for subsequent conversion into fibrous casing.

Another example is US Patent No. 3,433,633 which seeks to improve the quality of the viscose-bonded or wet-strengthened

manila hemp paper substrate, for subsequent fibrous cellulose casing manufacture, by using cellulose derivatives of high viscosity to provide stronger casings. The implication according to US Patent Specification 3,433,633 is clearly that the existing 22.7 g/m² substrates lack sufficient strength and therefore teach away from the use of lower substrate paper basis weights. Since 1989, significantly, patent specifications have appeared which chart the progress of applying alternative wet strengthening systems, other than those based on viscose, to treat the fibrous casing abaca fibre paper substrate, that is, using a variety of resin based systems. US 5,063,104 filed early in 1990 is one such example which also high-lights how paper physical properties may be affected in a dramatic or significant manner depending upon what wet strengthening binder or bonding method is substituted for viscose. One property which is affected significantly, and adversely so, insofar as the requirements of the present applicants' original specification of the present application is concerned, is paper stretch or elongation. Reductions of up to 20 to 50 percent for wet elongation from the levels obtained for viscose bonding of the paper were obtained in US 5,063,104, and fibrous casing elongation is very much dependent on the substrate paper's elongation. The present application describes a method to overcome the problems associated with reduced paper stretch which arises from the paper manufacturing process and process chemistry, that is insofar as the paper is treated, in order to make it strong and resistant to alkalis and acids in the wet state, for the casing manufacturer's purposes, as opposed to problems of say a self-inflicted nature on the part of the casing manufacturer. Now in order to make fibrous casings of ever-increasing diameter we have seen in the art prior to 1989 that the requirement for greater strength was met by the use of ever-increasing substrate paper basis weights and/or by the use of strength adjuncts to complement that offered by the viscose bond alone, for casings typically using paper weights of 17 g/m² and greater, whilst exceptionally the original specification presented paper substrates of 13 to 15 g/m² to make a range of light-weight casings from 32 mm diameter

up to 105 mm and indeed succeeded in extending the size to include casings with diameters up to 165 mm. In reversing this trend of using heavier weight paper to make wider diameter casings, that is reducing paper basis weight whilst reducing casing diameter, a limit is approached by virtue of the fact that a certain minimum paper strength in both dry and wet states is required in order that the paper will withstand draw tension so that it may be unwound from its roll, and thereafter possess sufficient wet-strength, following impregnation with the viscose of the casing manufacturer's process, so that it may successfully be converted into the casing product. Following the impregnation, the substrate paper tube, now saturated with viscose, has minimum strength and spends much of its time during its subsequent passage through the casing manufacturing machine as a flattened tube: the greater the surface area of this tube over turn-over rolls, which are used in the machine to convey it, and not all of which are necessarily driven, the less strength is required to convey it. These requirements for strength may be considered at variance: the larger the casing the easier it can be converted into casing using lighter weight substrate paper, but performing less robustly by the sausage-maker, whilst the narrower casing made with heavy-weight paper possesses adequate strength for the casing manufacturer's purposes, but may provide more strength than is required of the sausage-maker and be considered over-engineered, an expensive alternative as a result.

In order to obtain the desirable physical property mix of the subject casings of to original specification using resin-bonded papers of inferior, that is, lower, wet extension or elongation properties compared to substrate papers bonded with regenerated cellulose provided by viscose, that is prior to the viscose impregnation applied by the casing manufacturer, it has been found that substrate paper weights need to be reduced from 13 to 15 g/m² to preferably 10 to 12 g/m². Unfortunately this development at the same time takes the manufacturing process for the casing into uncharted water insofar as conventional viscose dies are usually engineered with robust and heavy papers in mind, where moderate paper web tensions applied by drive rollers exerted

over distances of several meters do not usually cause excessive so-called 'necking-in' of the tube, that is brought about by a simultaneous extension of the tube in its longitudinal direction and a commensurate shrinkage in its transverse direction, which is to say tube diameters are reduced from those defined by the die size. And unless steps are taken to overcome this obstacle the whole process of reducing paper weight to obtain more casing trans-directional extension becomes self-defeating. In order to overcome these difficulties using viscose dies normally used and designed for much heavier paper substrates, of say 21 g/m² of the prior art, it is possible to slow down the whole operation but this approach is not always convenient, and in certain cases may be considered somewhat self-defeating. The invention is now described in more detail with reference to the accompanying drawings in which:

Figure 1 shows how the tubing is manufactured by first forming the substrate paper into a tube and impregnating it with viscose ahead of the acid coagulation and cellulose regeneration bath.

Figure 2 shows the viscose die of Fig. 1 enlarged.

Figure 3 is a diagram showing the relationship between casing elasticity, paper weight and paper wet CD stretch of known tubing and tubing made according to this invention.

Accordingly, for the new generation of lightweight fibrous casings constructed of abaca paper substrates suitably wet-strengthened using viscose, and subsequently viscosed a second time by the casing manufacturer, that is in the original specification, a new arrangement of viscose die has been developed for the purpose of single-sided viscosing, which allows casing machine speeds to be increased over those operating for the casing examples in the original specification, at today's commercial levels, employed for conventional fibrous casing lines, whilst at the same time providing a superior impregnation of viscose during the casing manufacturing stage, to ensure smooth surfaces of both casing inner and outer surfaces is obtained, to render the need for double-sided viscosing unnecessary, or undesirable, in the case of these new generation light-weight casings.

When used for the subject casings of the present application, this new arrangement of die seeks to minimise drag upon impregnating the paper matrix with viscose, and, during the subsequent crucial period before coagulation of the viscose and its regeneration into cellulose has been completed, to the extent of thereafter permitting the casing to be stretched but not irreversibly. This is achieved by minimising the viscosed paper substrate-metal surface contact in the area of the die, and by judicious over-feeding of the paper to the inlet side of the die on the one and, while at the same time carefully controlling the paper draw or tension on the impregnated web on the lead-out side of the die on the other, to minimise the longitudinal extension of the substrate paper and obtain the subject paper embedded within the casing in a non-extended fashion. This new arrangement of viscose die, designed expressly for the purpose of impregnating lightweight papers in the 10 to 15 g/m² range, at line speeds faster than those previously used for treating lightweight paper substrates, will now be described with reference to Figure 1, against the background of those of the prior art which are regarded less than ideal for the subject casings. Paper, providing the casing substrate, is unwound from rolls delivered by the paper supplier in lengths of for example 10,000 meters, that is from paper rolls of weights from about 10 to 50 kg. With the assistance of paper unwind rolls, some of which are driven, the substrate paper is fed to the viscose die over metal guides at 7, see diagram, where it is formed into a tube, in such a manner as to keep the die over-fed with paper. The dimensions of the die are regarded critical for the reasons previously indicated, that is since they impinge on paper extension properties which are affected by frictional forces, or drag, in the region of the die directly following viscose-impregnation, and an important objective of the present application is to reduce the effects of such frictional forces to a minimum. Many of the die arrangements described in the prior art appear without dimensions except insofar as drawings of dies are presented but actual dimensions are often absent. And where actual dimensions have been given, most notably in connection with so-called double-sided viscossing methods, which

are not directly relevant to the present application, the ranges have been so wide as to describe non-critical situations. US Patent Application Nos 2,105,273 and 2,144,900 which appeared January 8th, 1938 and January 24th, 1939 are good examples of the former which for many years undoubtedly represented the state of the art of viscose die technology and indeed of fibrous casing manufacture. Sizing the dies of these specifications from their drawings suggests they are of a low viscose pressure type since the gap between the lips of the die, corresponding to dimension 1 of the dies of the present specification would be of the order of 2,5 to 3,0 mm for a die to produce a 45 mm diameter casing. Compared to dies used for many years by the present applicants the die described in these specifications would be regarded of robust design and suited to the requirements of substrate papers in the 21 to 28 g/m² basis weight interval, which characterized fibrous casing manufacture in the era under review. Such dies would not be expected to give rise to good viscose penetration of the paper substrate, and so it is not surprising that subsequent improvements tended to focus on higher pressure die technology, using narrower gaps between the lips of the dies to increase viscose velocities, and increasingly to focus attention on double-sided viscosing as in, for example US 3,709,720, where the two impregnations with viscose are conducted within a second or a fraction of a second of each other and where Kindl, its author, claims the apparatus such as that used in US 2,105,273 for single-sided viscosing, required adequate time for the viscose to penetrate the paper properly before beginning the cellulose coagulation and regeneration stages under acid, otherwise the poor penetration would have resulted in casings being produced of inferior strength and poorer transparency than where effective saturation of the tube with viscose is first carried out.

An objective of the present invention has been to retain the excellent viscose penetration properties offered by the higher pressure type of die, and thereby contain distances between die and coagulation baths to short distances of the order of 0,3 to 0,6 meters, but only by relying on the need for a single viscose impregnation in order to reduce drag between viscosed paper

substrate/ metal surface contact / viscose pressure forces in the area of the die involved with viscose penetration, that is at the lips of the die and directly following them. In order to reduce the effects of drag, paper lead-in and lead-out distances into and out of the area of viscose issue, from the lips of the die, have been kept small, and balanced with machine line speeds and paper basis weight, in an attempt also to achieve the best possible viscose penetration. Accordingly based on a fixed gap through which the viscose passes of 0,5 mm, dimension 1 in Figure 1, the gap between the lips of the die, both upwards and downwards in cylindrical disposition with the formed tube of paper and the face of the supporting metal ring or cylinder, 'c', is fixed at 0,5 to 0,7 mm and preferably 0,55 to 0,60 mm and regarded critical within the context of the other specified dimensions. This has been found suitable to accommodate the relatively narrow range of substrate paper thicknesses, in the range 50 to 80 μ m, and generally thinner than those of the prior art for 17 to 28 g/m² substrates.

It will be appreciated that the effects of frictional factors increase as basis weight decreases, whilst increased line speeds, which of necessity involve also increased draw or paper web tension, directly following viscose impregnation, since the draw is applied after the turn-over roll, 'd' in Figure 1, also increase the effects of friction. The paper lead-in distance has accordingly been set at between 10 mm and 5 mm in one preferred arrangement of the dies of the present application, dimension 3, Figure 1, depending on the basis weight of paper impregnated and the line speed used. With reasonable line speed running, viscose flow from the point of issue from the lips of the extrusion die, is predominantly downward with the paper, making a seal backwards from the die upper lip 'a' between paper 'b' and paper support 'c' with viscose. Similarly on the lead-out side of the die, the lip width, dimension 2 in Figure 1, of the present application, should be between 10 mm and 2 mm in conjunction with a paper support ring, 'c' in Figure 1, of 10 to 25 mm in length, supporting the paper on its approach to the area of influence of the die's upper lip and extending to a distance horizontal \pm 1-2 mm with the lower end of the lower lip in order

to contain frictional effects, the combined result of paper / viscose / metal contact-surface interactions which in turn interact with line speed and paper tension effects.

Despite the reduced metal surface contact of the lower lips of these new die arrangements and also of the metal ring paper support element, herein described, together with relatively short distances for the impregnated web to travel before entering the acid bath, but conducted at acceptably high speeds from the commercial standpoint as indicated elsewhere, no loss of quality is observed for the subject fibre reinforced casings either in terms of transparency, strength properties or otherwise. Indeed, rather the converse can be claimed and casings result which possess exceptionally good transparency, exceptionally high weight to strength ratios, and where there exists good evidence by way of Bendtsen smoothness measurements to suggest the physical property mix of the subject casings are of a superior order. So specified the die may be used to advantage to produce the subject casings in the paper basis weight interval from 15 down to 10 g/m² and whilst the longer metal-surface traverse, denoted as dimensions 2 and 3 in Figure 1, of respectively 10 and 10 mm at one end of the range, may be regarded as appropriate for the impregnating of 12 to 15 g/m² substrates at line speeds of up to 10 meters/minute, the shorter metal-surface traverse of 6 and 2 mm is regarded more appropriate for the impregnating of 10 to 13 g/m² substrates at line speeds of 10 meters per minute and greater. The benefit of these new die arrangements then, as will be shown shortly by way of examples, is to obtain similar casing tube extension properties from paper substrates, which rely more exclusively on resins such as the polyamide epihalohydrin types for their wet strength, rather than on small amounts of these together with the use of regenerated cellulose from viscose, or alternatively of regenerated cellulose from viscose used alone, that is because such papers possess inherently less stretch at a given basis weight. And to compensate for this reduced substrate paper stretch, paper basis weight has been reduced to a level of up to 30 to 40 percent lower, which advantage is lost unless the said paper can be treated in a manner which engenders less machine

or longitudinal direction tension during the crucial stages of paper impregnation, viscose penetration of the substrate, coagulation of the cellulose of the viscose and its attendant regeneration. Without the use of the new die arrangement the lighter-weight substrates tend to stretch excessively in their machine directions, particularly for smaller diameter casings running at high line speeds, which has the simultaneous effect of reducing their capacity for stretching in their cross directions. To understand the effect this has on casing strength one needs to consider the strength parameter of "toughness", alternatively referred to as "Tensile Energy Absorption" for which internationally recognized standards, such as that put out by TAPPI, the Technical Association of the Pulp and Paper industry in the United States of America, under the reference: T494 cm-81, and cross referenced with other standards published elsewhere. Simply put the toughness of a material may be defined as the work done when the specimen is stressed to rupture, in tension under prescribed conditions, as measured by the integral of the tensile stress over the range of tensile stretch from zero to maximum strain.

It is also clear from a study of the stress-strain properties of the substrate paper of fibrous casings that whilst the paper possesses a higher tensile strength in its machine, or length direction, compared to its cross direction, the paper may be said to be equally as tough in both directions by virtue of possessing more stretch in its cross compared to its length direction: that is the areas under their respective stress-strain curves are the same. Classical mechanics demands twice the strength in the hoop of a tube or hose compared to its length direction for good performance and a paper substrate possessing minimum sheet directionality has been the best approximation so far reached with a cellulose-based material, and it is the cross direction strength which is crucially important in a casing for subsequent meat stuffing and casing expansion purposes. Anything which detracts from maximising the cross toughness of a casing product, or anything which has the effect of reducing the size expectations from a given die-paper combination must be deemed to be counter-productive. And so for

these reasons the chief objective of the present application has been to produce casing products as far as possible similar to those in the original specification in terms of their stretch and performance properties but using so-called resin(s)- and viscose plus resin(s), as opposed to viscose-bonded paper substrates, using either dies of the prior art under certain operating conditions or the new die arrangements herein described, with improved performance.

Examples will now be presented which describe the tube properties sought. Table 1, and Diagram 1, pages 18 and 19 respectively show how the exceptional casing elasticity properties of VISKO LIGHT products based on abaca paper substrates, wet-strengthened by regenerated cellulose from viscose, together with a small amount of a polyamide epichlorohydrin resin, in the 13,0 to 15,4 g/m² basis weight range, and possessing paper cross direction wet stretch levels in the 9,6 to 13,2 % range, are essentially reproduced in casings of similar overall basis weight but based on abaca paper substrates wet-strengthened by resins, without the use of regenerated cellulose from viscose, which possess cross direction wet stretch levels in the 6,7 to 9,2 % but of significantly lower substrate paper basis weights in the 10,2 to 13 g/m² range. Elasticity is here defined as the capacity of the casing, after soaking in water at 40 degree Celcius for minutes, to expand from an uninflated condition to one of 25 inflation by 30 kPa air pressure, expressed as a percentage of the starting size. Generally speaking two aspects of light-weight casing construction are demonstrated by the data of Table 1, viz, that for a given size of casing, casing elasticity follows paper cross direction stretch at the same paper basis weight but that lower paper cross stretch can be compensated by lower paper basis weight to preserve casing elasticity levels when switching from a viscose and/or viscose plus resin(s)-bonded to a resin-bonded substrate, but not without fully taking into account casing machine tension effects, etc., as described above. Casing burst strengths for the new products based on resin-bonded paper compare favourably to those based on viscose-bonded paper in terms of strength per unit weight of substrate. Data is collected in Table 2, page 20, to

illustrate this: greater absolute strength is obtained for heavier substrate paper, but relative to paper weight, greater burst coefficients are obtained for the lighter substrates.

Casing Smoothness properties as determined using the Bendtsen method are shown in Table 3, page 21, for light-weight casings produced from viscose plus resin(s) and resin(s)-bonded paper substrates. The original specification pointed to significant differences between the Bendtsen smoothness properties of fibrous casings produced in accordance with the then prior art based on heavy-weight paper substrates of 17 to 23 g/m², and the light-weight viscose-bonded paper substrates of 13 to 15 g/m², the subject of Table 3A. Whilst the latter showed the lighter weight paper substrates gave rise to casings of smoother inside surfaces compared to those of the prior art, the results of the present application show there are no significant differences between viscose- and/or resin(s)-bonded paper substrates, in the 11,0 to 14,5 g/m² interval of paper substrate basis weight, incorporated in casings of 64,0 to 74,7 g/m².

TABLE 1

CASING ELASTICITY PROPERTIES AS A FUNCTION OF CASING SUBSTRATE
PAPER WEIGHT AND TYPE: VISCOSE PLUS RESIN- VERSUS RESIN(S)-WET
STRENGTHENED.

| Casing Size, diameter, mm /Paper Bonding Type | Substrate Paper Basis Weight, g/m ² | Paper Wet Cross Direction Stretch, % | Casing Weight g/m ² | Casing Elasticity at 0-30 kPa Inflation |
|--|---|---|--------------------------------------|--|
| 45/Viscose* | 13,0 | 13,0 | 74,6 | 14,6 |
| 45/Resin(s) | 10,2 | 9,2 | 72,5 | 14,1 |
| 50/Viscose* | 13,5 | 12,1 | 70,3 | 15,3 |
| 50/Resin(s) | 11,2 | 8,8 | 73,0 | 15,1 |
| 55/Viscose* | 13,2 | 11,0 | 72,2 | 16,7 |
| 55/Resin(s) | 13,0 | 7,4 | 77,4 | 13,2 |
| 55/Resin(s) | 10,8 | 8,4 | 73,8 | 17,5 |
| 60/Viscose* | 13,4 | 9,6 | 74,4 | 17,0 |
| 60/Resin(s) | 10,7 | 7,8 | 73,6 | 17,0 |
| 70/Viscose* | 14,9 | 11,3 | 78,2 | 19,2 |
| 70/Resin(s) | 12,4 | 8,0 | 76,2 | 18,3 |
| 80/Viscose* | 15,4 | 11,6 | 74,6 | 18,5 |
| 80/Resin(s) | 12,7 | 8,1 | 71,5 | 17,9 |
| 80/Resin(s) | 15,0 | 6,7 | 82,6 | 15,7 |

*Viscose here refers to viscose plus a small amount of a polyamide epihalogenhydrin resin, which resin can be seen not to affect substrate paper cross direction stretch, to an appreciable extent compared to the resin(s) of the exclusively resin(s)-bonded substrates, and indeed the higher values are typical of predominantly viscose-bonded paper whilst the lower typical of paper bonded without viscose.

TABLE 2

CASING BURST STRENGTH PROPERTIES AS A FUNCTION OF CASING
SUBSTRATE PAPER TYPE: VISCOSE PLUS RESIN- VERSUS RESIN(S)-WET
STRENGTHENED

| casing size, diameter (d)mm | paper base weight (w) g/m ² | casing weight g/m ² | casing burst strength (b) kPa | strength quotient (SQ) b/w | burst coefficient SQ . d. pi /100* |
|--------------------------------------|--|--------------------------------------|---|-------------------------------------|---|
| 45 viscose* | 13,0 | 74,6 | 78 | 6,0 | 8,5 |
| 45 resin(s) | 10,2 | 72,5 | 66 | 6,5 | 9,1 |
| 50 viscose* | 13,5 | 70,7 | 77 | 5,7 | 9,0 |
| 50 resin(s) | 11,2 | 73,0 | 79 | 7,1 | 11,1 |
| 55 viscose* | 13,2 | 72,2 | 71 | 5,4 | 9,3 |
| 55 resin(s) | 10,8 | 73,8 | 68 | 6,3 | 10,9 |
| 60 viscose* | 13,4 | 74,4 | 70 | 5,2 | 9,8 |
| 60 resin(s) | 10,7 | 73,6 | 57 | 5,3 | 10,0 |
| 70 viscose* | 14,9 | 78,2 | 65 | 4,4 | 9,7 |
| 70 resin(s) | 12,4 | 76,2 | 53 | 4,3 | 9,5 |
| 80 viscose* | 15,4 | 74,6 | 54 | 3,5 | 8,8 |
| 80 resin(s) | 12,7 | 71,5 | 52 | 4,1 | 10,3 |

*viscose here refers to viscose plus a small amount of a
polyamide epihalogenhydrin resin.

Table 3

| TUBING SMOOTHNESS PROPERTIES OF SUBJECT LIGHT-WEIGHT TUBINGS: Viscosa* versus Resin bonded Substrate Paper | | | | |
|---|--------------------------------------|------------------------------|-------------------|--------------------|
| PRODUCT | BENDTSEN SMOOTHNESS, cm3 air/minute | | | |
| diam. mm | Paper Weight, g/m ² | Tube Wt. g/m ² | Inside Surface | Outside Surface |
| 45 resin(s) | 11,0 | 72,8 | 750 | 170 |
| 45 viscose* | 13,0 | 73,2 | 950 | 190 |
| 50 resin(s) | 11,0 | 67,6 | 725 | 155 |
| 50 viscose* | 13,5 | 64,0 | 900 | 220 |
| 55 resin(s) | 11,0 | 74,7 | 900 | 145 |
| 55 viscose* | 13,5 | 70,0 | 850 | 220 |
| 60 resin(s) | 12,0 | 72,7 | 900 | 125 |
| 80 viscose* | 14,5 | 73,1 | 850 | 160 |

*Viscose here refers to viscose plus a small amount of a polyamide epihalogenhydrin resin.

TABLE 3A

TUBING SMOOTHNESS PROPERTIES OF SUBJECT LIGHT-WEIGHT
COMPARED TO INFERIOR (ROUGHER) PRIOR ART TUBINGS

| PRODUCT | | BENDTSEN SMOOTHNESS | | cm ³ air/minute | | |
|----------|------------------|---------------------|---------|----------------------------|---------|---------|
| SIZE | Subject Tubing | | | Prior Art Tubing | | |
| diameter | Weight | Inside | Outside | Weight | Inside | Outside |
| mm | g/m ² | Surface | Surface | g/m ² | Surface | Surface |
| 45 | 64,3 | 950 | 200 | 73,0 | 1080 | 290 |
| 50 | 63,7 | 900 | 220 | 70,0 | 1400 | 320 |
| 55 | 70,0 | 850 | 220 | 75,9 | 1080 | 310 |
| 80 | 72,5 | 870 | 220 | 96,4 | 1300 | 370 |
| 90 | 80,2 | 970 | 200 | 96,4 | 1100 | 310 |
| 105 | 73,0 | 850 | 160 | 92,1 | 1375 | 330 |
| 120 | 78,0 | 1025 | 180 | 96,8 | 1600 | 390 |

The principle of the Bendtsen smoothness test is to measure the amount of air, under a controlled pressure head condition, which can pass between a precision engineered annular ring measuring head placed on the surface whose smoothness is to be determined, whilst the test surface itself is placed in contact with a smooth support surface : such that without a test specimen in place no air is observed to flow, whilst test surfaces of ever rougher characteristics are observed to permit the flow of ever greater volumes of air.

Since the subject materials here are both of a porous nature, of course a component of the air flow will always pass through the test specimen and escape from under the measuring head from beneath the surface of the side in contact with the smooth specimen support, such that a lower flow for the outside surface, obtained above in the case of the subject light-weight tubings, reflects also a smoother inside surface, that is less leakage from the under-surface, than for the examples of the prior art: that the latter phenomenon is not related directly to basis weight can be seen by comparing air flows at the same casing basis weights, albeit for different sizes.

These and more practical manifestations of a tubing possessing a smoother inside surface, such as cleaner release of the untreated cellulose surface from meat proteins, attest to the improved construction achieved with the subject light-weight tubings.